4.0 V&V STATUS AND USAGE HISTORY

Suppressor has been used in a number of COEAs and other major studies, and there are currently over 65 registered user sites. Some of the major studies for which Suppressor has been used are briefly described in this section. There was also one significant Suppressor validation effort by the (now defunct) C3CM JTF, which is also described below.

4.1 V&V STATUS

The only formal Suppressor validation that has been documented was begun in 1987 by the C3CM JTF to support a project referred to as Test III [13]. The objective of Test III was to assess the effectiveness of U.S. C3CM against a Soviet Combined Arms Army Air Defense System. The test was conducted in two phases: Phase I was a field test conducted on the Nellis AFB complex in conjunction with Green Flag 87-3, and Phase II was a Suppressor simulation of a European scenario. In order to establish the credibility of the Suppressor modeling in Phase II, the Green Flag exercise was also modeled in Suppressor and numerous comparisons between the exercise and model results were made to validate the model.

In addition to the comparisons between field test and model results, several other activities contributed to the overall validation. One activity was simply a review of input databases for accuracy. This consisted of a straightforward, but tedious, comparison of input data items to source references. A second activity consisted of sensitivity analyses in which small "vignettes" consisting of one-on-one or one-on-few engagements were modeled and examined to determine whether they produced expected results.

The Suppressor data bases needed to replicate the Green Flag exercises were developed from a variety of sources. Equipment parameters for the threats were obtained from intelligence documents and validated TAC Repeller data bases. Parameters for blue systems were obtained from the Multi-Command Manual (MCM) 3-1 and supplemental sources. Terrain data was obtained from the DMA DTED, and flight paths were reconstructed from Time-Space-Position Information (TSPI), pilot debriefs, navigator logs, and mission monitors.

The characterization of human factor data for the threat such as decision logic and reaction times in Suppressor required special consideration. These data are typically unavailable in intelligence assessments, so an analysis of the Green Flag (and previous Red Flag) exercise data was required to obtain representative values. Based on this analysis, eight factors were determined to have significant impact:

- Message transmission time
- Time to achieve lock-on
- Time from lock-on to launch
- Time between missiles in a salvo
- Frequency change criteria and time to reconstitute a net
- Decentralization criteria
- Time to establish a track (acquisition radars)
- Coast time (time before dropping a target).

The resulting tables of numerical values were documented in a BDM report [14].

The Nellis threat laydown for the Green Flag exercise consisted of a simulated army command post, an SA-4 brigade, and the air defense assets of two Soviet divisions. The 1st-echelon division was defended by an SA-8 regiment and an Anti-Aircraft Missile and Artillery Battery (AAMAB) consisting of SA-9s and ZSU-23-4s. The 2nd-echelon had an SA-6 regiment and an AAMAB. In total, there were 20 threats, 15 command nodes, and 13 early warning/acquisition radars positioned and operated in accordance with Soviet doctrine and procedures.

The blue attack force consisted of approximately 65 aircraft per trial plus several ground-based communications jammers. The aircraft included F-16, F-4, A-7, F-111, and Tornado ground attack aircraft, F-15, F-5, and F-4 fighters, EF-111, Compass Call, Volant Solo, and Quick Fix airborne jammers, plus Wild Weasels, RF-4Cs, and B-52s. The ground-based comm jammers included the AN/MLQ-34, AN/TLQ-17A, and AN/ULQ-19.

The validation compared the results of two exercise trials (which used different attack tactics) to Suppressor results. Detailed comparisons were made in six areas.

- Basic (non-ECM) communication performance
- Communication performance with reactive jammers--this comparison examined jammer assignments, jammer signal strengths at the victim, and counter-countermeasures by the victim such as changing to alternative frequencies and assuming autonomous control.
- Radar coverage--this looked at EF-111 noise jamming effectiveness as a function of standoff range and jammer angle with respect to attack aircraft.
- Rules of engagement--this compared target assignment and engagement decisions based on target position within defined zones.
- Weapons Pks--this compared conditional probabilities of kill given a shot obtained from the Enhanced Surface-to-Air Missile Simulation (ESAMS) and input to Suppressor with the results of range flyout models.
- Engagement results--this compared number of engagements, shots, and hits by threat type.

Overall, the results between the model and Green Flag exercise agreed quite well, and the JTF concluded [13]:

> "Comparisons of engagements, firings, and hits by system showed that the relative number of events for the field test trials and the simulations followed the same trends and, generally, the absolute numbers were very close."

4.2 USAGE HISTORY

Tacit Rainbow COEA. The Tacit Rainbow COEA was one of the first major studies to use Suppressor. This COEA was started in 1988 with Suppressor 5.0 and was led by ASC. The Tacit Rainbow Program Office invested significant resources adding and improving

features in Suppressor to better describe emission control and electronic combat. These improvements focused on radar modeling, EMCON, and jamming. Initially, Suppressor 5.0 was modified and the resulting version, called BOW 2.0, was used in 1988 and early 1989. Later, modifications were made to Suppressor 5.1, and this modified study version of Suppressor was designated BOW 3.0. Used for Tacit Rainbow COEA analysis from late 1989 through 1991, these improvements were later integrated into Suppressor 5.2.

ASPJ COEA. Another major COEA to use Suppressor for mission-level effectiveness analyses was the AN/ALQ-165, Airborne Self-Protection Jammer (ASPJ) COEA led by the Naval Weapons Center (now NAWCWPNS), China Lake. One interesting aspect of this study is that the Operational Test and Evaluation Force (OPTEVFOR) used the COEA scenarios to plan the flight profiles in the operational evaluation and subsequently input the SAM Pks (with and without ECM) into Suppressor to derive mission-level effectiveness results.

Tomahawk COEA. Suppressor was formally certified for use in the Tomahawk COEA in FY94 at NAWCWPNS, China Lake. The certification consisted of a review of Suppressor 5.3 algorithms and code and a comparison of Suppressor results for a number of one-on-one and many-on-many test cases with results from the Striker simulation (McDonnell Douglas) and the Multi-Battlefield Engagements and Reactions (MBER) simulation (Applied Physics Laboratory). MBER had been previously certified for Tomahawk analysis and was the baseline model for the Suppressor certification. In order to make a consistent comparison between models, several model-specific features in Suppressor and Striker had to be disabled. Overall the agreement between Suppressor and MBER was acceptable and Suppressor was certified for the Tomahawk COEA.

A number of Suppressor limitations were identified in the Tomahawk analysis, and several were subsequently funded for correction through the FY95 Joint Advanced Strike Technology (JAST) Model Improvement Program. One of these changes was to permit more than one command chain in the ASG-CMD-CHAIN data item so that when a commander in one command chain is killed or loses communications, a commander in another command chain can assume command. This is a more flexible representation of degraded command and control than previously offered by the ALT-CMDRS data item. A second limitation was the restriction that all communications must go vertically up or down a command chain. A PEER communications option was added to correct this limitation. These enhancements were distributed as code changes to version 5.3 and subsequently incorporated into Suppressor 5.4.

B-1B CMUP COEA. The Institute for Defense Analyses (IDA) selected Suppressor for use in the B-1B Conventional Mission Upgrade Program (CMUP) COEA. The study was begun in 1994 with version 5.2 of Suppressor but was interrupted by congressional tasking to perform a more comprehensive heavy bomber study. After the conclusion of the heavy bomber study, the B-1 COEA was resumed with version 5.3, and a final report was released in November 1996 [15].

The Suppressor data bases used by IDA were originally obtained from the ASC/XRE. The radar characteristics and engagement timelines were extensively checked against published DIA threat assessments and corrected where necessary. Suppressor was used to generate probability of survival response surfaces which were functions of threat types and numbers.

These response surfaces were subsequently used as inputs for the campaign-level modeling and analysis.

Several Suppressor limitations were identified in the early phases of the analysis, and appropriate code modifications were implemented. One of the changes involved the addition of the LAUNCH-ENVELOPE and INTERCEPT-ENVELOPE data items to the RESOURCE-ALLOCATION criteria. This change allows the definition of geographical regions around weapon locations that can be used to determine whether a particular engagement-related action should be performed or terminated. The second change was the addition of a WPN-TIME-DELAY-TABLE in order to implicitly model the "rail-keeping" effect[1] of ECM. The third change was the addition of a WPN-PK-DEGRADE data item. This table allows multiplicative degrade factors to be used for ECM effectiveness rather than creating separate WPN-PK tables with and without ECM.

Joint Tac Air Electronic Warfare Study (JTAEWS). In 1993, the Deputy Secretary of Defense directed the Air Force and Navy to initiate a study to identify common electronic warfare requirements for tactical aircraft for the next 20 years. The AFSAA led this study and developed an analysis and modeling methodology that used Suppressor for the mission-level effectiveness analysis. Three separate missions in the context of a Southwest Asian scenario were chosen for analysis. The threat laydown was an excursion of the Multi-Spectral Force Deployment (MSFD) data base specifically approved by the DIA for this study, and blue strike packages, flight paths, and tactics were developed by service-representative mission-planners. The initial Suppressor data bases for the study were obtained from ASC/XRE but were subsequently modified by AFSAA for the study. A two-volume report has been written, but distribution is limited.

B-1B DSUP Requirements. In a separate B-1B study, AFSAA was tasked by the ACC to analyze B-1B ECM requirements for the B-1B DSUP. Suppressor 5.3 was selected for use in this study based upon its previous use and data base development by AFSAA in the JTAEWS. Very extensive missions for various snapshots in a Southwest Asian campaign were planned by mission planners on the CENTCOM staff using the DIA-approved MSFD data base for the year 2005. The primary mission-level MOE was the number of targets at risk for a specified mission success rate. No significant model deficiencies were noted; however, air-to-air effectiveness was not modeled. Results of this study have been briefed up the AF chain of command, and a final report is in draft status.

RAND (SEAD) Study. Suppressor 5.3 was used by RAND to analyze the relative mission-level effectiveness of several SEAD alternatives for the Air Force. The primary focus of the analysis was to compare the AN/ALR-49 on the F-4G Wild Weasel, the HTS on the F-16, and the PDF system proposed for the F-15, but the relative effectiveness of chaff and self-protection jamming, standoff jamming, HARM, decoys, and combinations of the these alternatives were also examined. Two Southwest Asian scenarios were modeled--one represented a pre-Desert Storm Iraqi order of battle and the second was based on the 2010 MSFD. A number of sensitivity analyses were performed which looked at different command and control states, different threat EMCON doctrine, and different strike tactics. Force attrition (both threat and friendly) was the primary MOE, but other MOEs were also used to support the attrition results [16].

1. "Rail-keeping" is a term used to describe the reduction in number of weapon shots attributed to ECM.

Several Suppressor errors and limitations were discovered in the course of the RAND study. One of the errors involved the selection of targets by disaggregated players. HARM missiles were modeled as disaggregated players, and although they were launched at specific emitters, they would ignore the assigned target and engage the first target autonomously detected. This problem was corrected by SAIC.

One modification made by RAND was to add a new dimension to the WPN-PK table to allow different HARM Pk values for different target range qualities as determined by the HARM targeting sensors. This modification was not sufficiently general to justify inclusion into the configuration managed version.

JSOW COEA. NAWC Weapons Division, China Lake used Suppressor to perform the mission-level effectiveness analysis for the JSOW P3I COEA. NAWC was provided scenario data for this study but developed their own strike missions with help from Navy planners. No official accreditation was required, and no significant problems or limitations were documented in the final report [17].

JASSM. Suppressor version 5.3 was accredited by the Air Force Chief of Staff in April 1995 for use in trade studies of the JASSM. This accreditation was based on Suppressor's use by both the Air Force and Navy in previous studies and on the availability of the Southwest Asian scenario previously developed under JTAEWS. Suppressor was determined to provide a reasonable representation of key weapon system capabilities; however, three model improvements were recommended. These were improved anti-aircraft artillery modeling, in-flight weapon guidance, and endgame maneuvering.

4.3 IMPLICATIONS FOR MODEL USE

Suppressor has been used in a variety of mission-level assessment efforts by both the Air Force and Navy, and more recently, for joint programs. Results from these analyses have undoubtedly been used to make procurement or development decisions concerning several weapon systems or platforms. This level of usage is evidence of the wide acceptance of Suppressor as a mission-level analysis tool. Many improvements to the simulation have been made as a result of suggestions or requirements resulting from these studies. A list of current Suppressor users is presented in Appendix C.

Validation of a mission-level simulation is not a simple matter, given the broad range of platforms, scenarios and tactics that can potentially be simulated. Although only one formal validation effort has been conducted, the results of that effort did show close agreement between Suppressor results and test data in the scenario examined. The Tomahawk COEA model certification work, also demonstrated agreement between Suppressor results and those of some other accepted models.